

SOUTHWEST RESEARCH INSTITUTE ASSISTANCE TO NASA IN BIOMEDICAL AREAS OF THE TECHNOLOGY UTILIZATION PROGRAM

QUARTERLY PROGRESS REPORT #3

Period Covered: 1 August 1969 - 31 October 1969

Contract No. NASW-1867
SwRI Project No. 13-2538

Prepared for

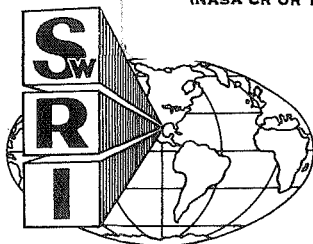
Chief, Dissemination Branch, Code (UT)
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SOUTHWEST RESEARCH INSTITUTE
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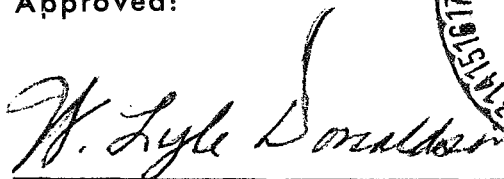
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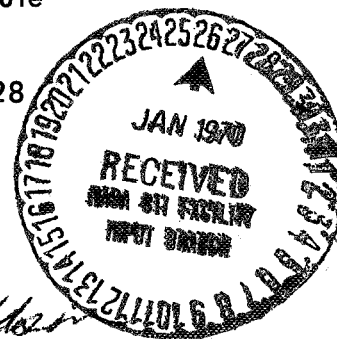


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A. INTRODUCTION

1. General Background

The aeronautical and space activities conducted by the National Aeronautics and Space Administration (NASA) are creating an impressive body of knowledge of great potential scientific and technological usefulness. In carrying out its congressional mandate to disseminate this information for ultimate benefit of the general public, NASA has engaged in an extensive publications program; in particular, publications under the auspices of NASA's Technology Utilization Division (TUD) are specifically aimed at expeditiously transferring NASA developments to the scientific and industrial community.

Special difficulties are encountered when it is attempted to transfer NASA-derived technology, by means of TUD publications alone, to scientists in the biomedical fields. These scientists are particularly overburdened by the copious amounts of published biomedical material; additionally, they are by and large unfamiliar with the language and symbology of the physical and engineering sciences. As a result, technology in physical science and engineering has often not been as effectively transferred to biomedical applications as it deserves to be.

The TUD's investigations of the chain of events leading to the introduction of new products, technological inventions, and methods into medical practice have suggested that the biomedical research teams at medical schools and similar biomedical research institutions play a key role in this process. New discoveries, introduced by these groups, tend to proceed naturally through stages of professional approval, manufacturing interest and participation, on to the level of the practicing physicians, bringing direct health benefits to the public. It would seem an attractive goal to introduce NASA-derived advances at the level of the biomedical research team, and thus to utilize the existing channels to the medical practitioner and his patients for effective technological transfer.

As a result of these investigations, NASA's TUD has developed a general methodology for the solution of this important and special technological transfer problem. Prominently included in this methodology was the establishment of several strategically placed Biomedical Application Teams consisting of appropriately cross-trained and broadly experienced physical and biological scientists. It is the task of the Biomedical Application Team to facilitate and improve the productive interaction between NASA centers and biomedical research teams. Emphasis is on interpersonal contact, in which the cross-trained members of the Biomedical Application Team form an active link between these two groups of scientists. A flexible system is maturing in which both principal groups, NASA personnel and biomedical

researchers, freely and effectively participate in mutually beneficial exchange of skills and knowledge.

2. Participating Personnel

The following scientists are participating in the program:

- Southwest Research Institute Biomedical Application Team
- Southwest Research Institute Personnel (see Table I):
 - Ray W. Ware, M. D., Director
 - Louis S. Berger, Project Manager
 - W. R. Brian Caruth
 - Robert J. Crosby
 - David F. Culclasure
 - Charles J. Laenger, Sr.
 - Samuel G. Schiflett
 - Betty J. Wall
 - Andre G. Buck (West Coast)
- Key Coordinators at User Institutions:
 - F. Hermann Rudenberg, Ph. D., Associate Professor,
Department of Physiology, The University of Texas
Medical Branch, Galveston, Texas
 - Jack B. Johnson, Chief, Biomedical Instrumentation
Section, Southern Research Support Center,
Veterans Administration, Little Rock, Arkansas
 - Mr. John Hall, Seattle Handicapped Center,
Seattle, Washington
 - Mr. Don Baker, University of Washington, Department
of Bioengineering, Seattle, Washington
 - Mr. H. A. Miller, Stanford University School of Medicine
 - N. P. Thompson, M. D., Palo Alto Medical Research
Foundation
 - Marcus J. Fuhrer, Ph. D., Departments of Physical Medicine
and Rehabilitation, Texas Institute for Rehabilitation
and Research
 - V. Mooney, M. D. (SRS), Rancho Los Amigos Hospital,
Downey, California

<u>Team Member</u>	<u>Institute Department and Section, Title</u>	<u>Technical Expertise</u>	<u>Team Function</u>	<u>Percent Time On Project</u>
Ray W. Ware, M.D.	Manager Medical Instrumentation Research Section Department of Bio- engineering	Medical Instrumentation, physiologic monitoring; aerospace medicine	Director	25%
Louis S. Berger	Senior Research Engineer Medical Instrumentation Research Section Department of Bio- engineering	Communications processes; language perception; mathematical	Project Manager	80%
W. R. Brian Caruth, Ph.D.	Manager Operations Research Department of Electronics Systems Research	Operations Research	Data acquisition and analysis	5%
Robert J. Crosby	Biomedical Research Engineer Medical Instrumentation Research Section Department of Bio- engineering	Electrical Engineering; extensive experience and additional training in bio- medical engineering	Problem Coordinator	25%
David F. Culclasure, Ph.D.	Senior Research Psychologist Medical Instrumentation Research Section Department of Bio- engineering	Human learning and motivation; perception; psychometrics	Problem Coordinator preparation of instructional (briefing) material	50%

TABLE I

<u>Team Member</u>	<u>Institute Department and Section, Title</u>	<u>Technical Expertise</u>	<u>Team Function</u>	<u>Percent Time On Project</u>
Charles J. Laenger, Sr.	Senior Biomedical Research Engineer Medical Instrumentation Research Section Department of Bio- engineering	Electrical engineer; cross- trained in biology; medical instrumentation	Problem Coordinator	70%
Samuel G. Schiflett	Research Scientist Medical Instrumentation Research Section Department of Bio- engineering	Experimental psychology; zoology	Problem Coordinator	40%
4 Robert E. Schuhmann	Senior Research Physiologist Artificial Organs Research Section Department of Bio- engineering	Cardiovascular physiology; mechani- cal engineer	Problem Coordinator	20%
Betty J. Wall	Assistant Research Scientist Medical Instrumentation Research Section Department of Bio- engineering	Information handling; editorial skills, behavioral science	Data analysis; report prepara- tion; participa- ting team member on selected problems	100%
Andre G. Buck	Senior Research Engineer Medical Instrumentation Research Section Department of Bioengineering	Electrical engineer	Problem Coordinator; participating team member on selected problems	25%

TABLE I (Cont'd)

- Other Southwest Research Institute Staff consulted this quarter:
 - . Fred M. Dickey, Research Engineer, Industrial Systems Section,
Department of Instrumentation Research
 - . C. Gerald Gardner, Ph. D. , Senior Research Physicist, Non-
destructive Evaluation Section, Department of Instrumen-
tation Research
 - . W. L. Rollwitz, Manager, Electronic Instrumentation Section,
Department of Instrumentation Research

B. SUMMARY OF PROJECT ACTIVITY AND METHODOLOGY

1. Biomedical Problems

During the current reporting period, seven new problem submission forms were submitted by biomedical researchers. Of these, six have been accepted for processing (BLM-12, BLM-13, BLM-14, BLM-15, DVM-1, and TCM-1). We were unable to accept one problem (SFM-9P), since commercially available tape recorder equipment was entirely satisfactory. A letter was sent to the Problem Originator, advising him that the problem was not accepted for processing and explaining that a problem cannot be accepted for which adequate commercial solutions exist. Some information on commercial recorders was furnished to the Problem Originator.

Twenty-seven problems were active during this quarter; of these, seven were inactivated for the reasons described in Section C. 3. In addition, seventeen old problems had very minor activity.

Processing problems requires a great amount of communication. A total of 58 telephone calls, 105 letters, and 25 visits, all directly relevant to problem processing, were made. Of these, 25 transactions related to follow up activity (16 calls, 2 visits, and 7 letters). The overall problem activities are presented in Section C. , and detailed, "raw data" chronologies on all 44 problems will be published separately in the Case History Supplements #3.

No Medical Problem Statements were disseminated through the NASA Research Centers during this quarter. Six new Medical Problem Statement drafts (BLM-12, BLM-13, BLM-14, BLM-15, DVM-1, and TCM-1) were prepared but have not yet been disseminated. They are included in Section C. 5. There are now ten drafted but not as yet finalized or disseminated new statements, including those prepared in the previous quarter.

2. Center Responses

Table II summarizes the response activity this quarter on the eleven circulated Medical Problem Statements. Evaluations of these responses are proceeding, as discussed in Section C. 4.

Problem	NASA Centers										Total
	Headquarters	MSC (Houston)	Lewis	Langley	Kennedy	SNPO	Marshall	JPL	Ames	ERC (Cambridge)	
GLM-3											0 (Closed)
GLM-9											0 (Closed)
GLM-14						1	1			1	3
GLM-15		1	2			1	1	1			6
GLM-19		1	3								4
GLM-20				1					1		2
NWR-5			1				1		1		3
SRS-8B	1			1	1						3
RNV-14				4							4
WSM-1	1				1						2
HUV-17				1	1						2
Total	2	2	6	7	3	2	3	1	2	1	29

TABLE II

3. Communications with New Institutions

Contact with new institutions usually takes place in two steps: an informal, explanatory visit to the dean or other representative administrative officers, and, if indicated, a later briefing to interested staff members.

Initial visits or other contacts were made at the following institutions:

- a. University of Texas Dental Branch at Houston:
R. W. Ware - 19 August (visit)
- b. University of New Mexico Medical School:
L. S. Berger - 19 August (visit)
- c. University of California at Davis:
C. J. Laenger - 23 September (visit)
- d. University of Utah School of Medicine:
L. S. Berger - 16 October (visit)
- e. University of Colorado School of Medicine:
R. W. Ware - 21 October (telephone call)
The administration prefers to receive information on the program by mail and then go directly to the briefing phase, should they consider it to be appropriate after examining the program descriptive material.

Briefings were presented at the following potential user institutions:

- a. University of Texas Dental Branch at Houston:
C. J. Laenger and L. S. Berger - 2 October (visit)
- b. University of Arizona College of Medicine:
C. J. Laenger and L. S. Berger - 18 October (visit)
- c. University of Texas Southwest Medical School:
C. J. Laenger, R. E. Schuhmann, L. S. Berger - 29 October (visit)

The results of the contacts mentioned above were:

- a. University of Texas Dental Branch at Houston: no response as yet; follow up letter sent.
- b. University of Texas Southwest Medical School: no response as yet; second briefing is being planned.
- c. University of Arizona College of Medicine: one problem submitted.
- d. University of Utah School of Medicine: staff briefing is being arranged.

- e. University of California at Davis: one problem submitted; staff briefing is being planned.
- f. University of Colorado School of Medicine: requested material has been sent; we are waiting for a reply.

4. Methodology

A user brochure was prepared. It serves to inform a problem originator, in some detail, what benefits are available to him, what procedures are followed in aiding him, and what his obligations as a participant are.

To unify and facilitate the project procedures within Southwest Research Institute, a Standard Operating Procedures Manual was prepared and distributed to Team members. Copies were forwarded to the project technical monitor.

C. PROBLEM STATUS SUMMARY

1. Actual Transfers

A transfer has been made on problem SFM-3, "Improved Monitoring of Heart Cell Parameters." For a copy of the Transfer Report on this problem, please see Appendix B.

2. Potential Transfers

Seven potential transfers were identified during this quarter. Since details of the potential transfer situation are discussed in the respective problem status summaries, the potential transfers are presented in the following list for reference convenience only.

GLM-14 ■ "Repetitive Measurement of Kidney Mass in Intact Animal"

Responses to the Medical Problem Statement dissemination suggested approaches using ultrasonics. These appear to be quite promising and are being pursued.

GLM-15 ■ "Respiration Volume and Rate Measurement in Unencumbered (Free) Child"

It is possible that careful reengineering of technology developed at Electronics Research Center may make the Center device applicable to this problem.

GLM-16 ■ "In-Situ Tumor Mass Determination on Rat Leg"

Responses to the Medical Problem Statement dissemination suggested approaches using ultrasonics. These appear to be quite promising and are being pursued.

BLM-12 ■ "Flexible Material for Connecting Electrical Stimuli to Nerves, Without Damage"

The use of techniques developed at Langley Research Center and those developed at Ames Research Center are being evaluated.

BLM-13 ■ "Nonthrombogenic Material for Use As A Blood Interface"

There is a good possibility that appropriate samples of NASA developed biocarbons will be made available for evaluation to the Problem Originator and that they will meet his needs.

WSM-7 ■ "Sensitive Detection for Human Electric Field Application"

A sophisticated high cost facility at Ames Research Center may become available to the Problem Originator for a limited series of experiments. Although the research area relates to electromagnetic rather than electric fields, research results may have direct bearing on the submitted problem.

NWR-5 ■ "Numerical Methods for Solutions to Wave Equations in Layered Media of Arbitrary Cross Section"

Mr. John H. Lynch, NASA Plum Brook Station (Reactor Division), has been interacting with the Problem Originator and furnishing him with detailed analytic mathematical material. Feedback requests to the Problem Originator were made 21 August, 11 September, 6 October, and 20 October. Interest in this problem was also expressed by staff at Ames Research Center, Analysis Computation Branch.

3. Problems Inactivated

Seven problems were inactivated during this reporting period. The following list presents the problem titles and the reasons for their inactivation.

Texas Institute for Rehabilitation and Research

HUV-1 ■ "Reduced Workload Environment for Physically Handicapped Patients"

During a telephone conversation with the institutional consultant, it was established that the main activity on this project is preparation of the final report. No further team activity is indicated until report preparation is completed. At that time, the document will be made available to the team for supplementary transfer information. Whether or not any follow-on action is indicated will be determined at that time.

HUV-18 ■ "Microanalysis of Mucous Secreting Cells"

Transfer information was obtained from the Problem Originator and officials at the Manned Spacecraft Center. Documentation of the transfer processes is complete, and the problem is closed.

The University of Texas at Galveston

- GLM-3 ■ "Determination of Local Blood Flow, Blood Gas Concentration, and Blood pH in Small Portion of An Organ"

Since no response was received to the Medical Problem Statements disseminated 25 July 1969, this problem was closed.

- GLM-9 ■ "Measurement of Local Tissue Oxygen Consumption In Vivo"

Since no response was received to the Medical Problem Statement disseminated 25 July 1969, this problem was closed.

- GLM-17 ■ "Respiratory Gasses Measurement"

The Problem Originator will, for the time being, use commercial equipment. Therefore, this problem has been classified "Inactive. "

The University of Texas Medical School at San Antonio

- SNM-1 ■ "Enhancement of X-Ray Contrast Study Films"

The lengthy history of this problem is documented in detail in the case history entries over the past two and one-half years. Since, for a variety of reasons, no progress has been possible to date, this problem was inactivated, pending initiative by Jet Propulsion Laboratory.

Rancho Los Amigos Hospital

- RNV-12 ■ "Body Temperature Regulation in Congenital Amputees"

A new researcher has taken over the project associated with this problem, and he requested during a telephone conversation with a Team member that the problem be considered closed. The researcher has no plans to pursue the problem area at this time.

4. Status Summaries of Active Problems

TEXAS INSTITUTE FOR REHABILITATION AND RESEARCH

Title: "Analysis of Human Motion Patterns"

Problem Originator: R. E. Herron, Ph. D., Associate Professor, Texas
Institute for Rehabilitation and Research, Houston, Texas

Date Submitted: 29 October 1969

Description of Problem: A system is desired to automatically describe, in three dimensions, human motion patterns. Applications would pertain to the analysis of normal individuals and patients with various forms of motor disorders. The therapeutic goal is to restore the normal pattern of motion to an affected individual. It would be desirable to measure the patient before, during, and after therapy and to analyze and relate the described motions to a normal pattern of movement. The desired technique should be capable of measuring the kinematics of body segments by noncontacting methods or low inertia "markers." The system should include a means of automated data processing in order to obtain a complete space-time history of selected locations on the body surfaces.

Activity on Problem to August 1, 1969: Mr. C. J. Laenger, the Problem Coordinator, met with Mr. W. Van Der Veer of the Applied Physics Department of Southwest Research Institute and discussed the applicability of the Armour cattle grader system to the gait analysis problem. However, since this information was classified Indus-Secret, no information could be released. A Medical Problem Statement was then printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Upon receipt of the information from Kennedy Space Center that several experiments conducted in the Apollo Applications Program (at Manned Spacecraft Center) might be appropriate to the problem, action was taken to obtain information from NASA concerning the experiments.

Projected Problem Activity: Forward any information obtained on the Apollo experiments to the Problem Originator.

THE UNIVERSITY OF TEXAS MEDICAL BRANCH, GALVESTON

Title: "Repetitive Measurement of Kidney Mass in Intact Animal"

Problem Originator: Dr. Wiktor Nowinski, Research Professor of Biochemistry,
Department of Surgery, University of Texas Medical
Branch, Galveston, Texas

Date Submitted: 8 August 1967

Description of Problem: It is general observation that after removal of one organ of a paired organ (lung, kidney, etc.) the remaining organ increases in size and performance in order to somewhat compensate for the loss of function caused by the other's removal. This is true of the kidney and is termed compensatory hypertrophy. A method is needed for the periodic measurement of the mass of the kidney in a live animal so that the mechanisms of compensatory hypertrophy after surgical removal of one kidney may be studied.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator. Upon examination of the search results the Problem Originator stated that he was unable to spend the time and money to follow up the suggestions in the search results. A Medical Problem Statement was then printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: A digest of responses from Marshall Space Flight Center, Space Nuclear Propulsion Office, and Electronics Research Center were evaluated and discussed with the Problem Originator. An "ultrasonic scanning" approach was suggested by investigators at two separate NASA Research Centers. Upon the request of the Problem Originator for more information from NASA on "ultrasonic scanning" techniques, it was learned that an "ultrasonic scanning gun" which may be applicable to kidney or tumor mass measurement is at Marshall Space Flight Center and that a "hand-held ultrasonic bone scanner" is still in the prototype stage. Mr. James W. Wiggins, Technology Utilization Office at Marshall Space Flight Center promised to send equipment specifications but no ultrasonic hardware. Dr. David S. Gabriel, Deputy Manager, Space Nuclear Propulsion Office was contacted for names of ultrasonic experts at various NASA centers. Dr. Gabriel turned the matter over to Mr. Samuel Snyder, Technology Utilization Office at Space Nuclear Propulsion Office, who is checking up on various leads at Aerojet, Sacramento.

Projected Problem Activity: Arrangements will be made with ultrasonic experts in the NASA Research Centers and with NASA contractors to begin negotiations with the Problem Originator for a possible loan of equipment.

Title: "Respiration Volume and Rate Measurements in Unencumbered (Free) Child"

Problem Originator: Roy D. Wilson, M.D., Assistant Professor, Department of Anesthesiology, University of Texas Medical Branch and Shrine Burn Center, Galveston, Texas

Date Submitted: 19 August 1967

Description of Problem: A method is needed for measuring the rate and depth of breathing of children who are suffering from severe burns on the upper half of their bodies. The method should not involve connecting tubing to the nose or throat, nor enclosing the body in a plethysmograph. The ideal method would allow measurement of the tidal volume (the volume of air moved into and out of the lungs with each breath) without adding any resistance to the airway and without touching or irritating the skin.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made and the search results were forwarded to the Problem Originator. No new information was obtained from the search results. It was learned that Electronics Research Center had a respirometer which might be of value in this problem. The device was loaned to the Problem Originator by Mr. Fred A. Hills of the Technology Utilization Office. The applicability of the device was negative since it appeared to have pick-up and calibration problems. The respirometer was returned to Electronics Research Center. A Medical Problem Statement was printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Responses to the circulated Medical Problem Statement were received from Marshall Space Flight Center, Lewis Research Center, Jet Propulsion Laboratory, Space Nuclear Propulsion Office, and Manned Spacecraft Center. It was discovered that impedance pneumography hardware (from Gemini and/or Apollo) might be made available to the Problem Originator. Correspondence with the Electronics Research Center stated that no further development work is planned for their respiration monitors.

Projected Problem Activity: By reengineering, it may be possible to devise a suitable transducer assembly.

Title: "In-Situ Tumor Mass Determination on Rat Leg"

Problem Originator: A. E. Rodin, M.D., Associate Professor of
Pathology, University of Texas Medical Branch,
Galveston, Texas

Date Submitted: 11 October 1967

Description of Problem: In the study of the influence of certain drugs and treatments on the growth or destruction of tumors, cancer researchers need a non-destructive method for measuring the mass and/or volume of tumors in the legs of experimental animals. It is desirable to make measurements without anesthesia and excessive handling and with as little restraint as practicable. Factors which could affect growth of the tumor must be avoided since they might obscure or invalidate interpretation of the influence of the drug under test.

Activity on Problem to August 1, 1969: Certain aerospace technology developed at Southwest Research Institute, which was thought might offer a potential solution to the problem, was ruled out after trial. Difficulty in obtaining accurate mass measurement made application of the device unacceptable. A WESRAC computer search of NASA technology was then made but the search results held little of interest. A Medical Problem Statement was printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: The Medical Problem Statement was not disseminated to the NASA Research Centers by the Sponsor due to a similar problem (GLM-14) recently circulated to the NASA Research Centers. The Medical Problem Statement will be held at NASA Headquarters pending evaluation of the responses to GLM-14 by the Problem Originator of GLM-16.

Projected Problem Activity: Obtain an evaluation by the Problem Originator of the responses to the circulated Medical Problem Statement on GLM-14.

Title: "Measurement of the Velocity of Myocardial Contractions by Noninvasive Means"

Problem Originator: Quang X. Nghiem, M.D., Assistant Director,
Pediatric Cardiology, University of Texas Medical
Branch, Galveston, Texas

Date Submitted: 10 October 1968

Description of Problem: The contractility of the myocardium is an ill defined characteristic that refers to several aspects of the act of shortening of the myocardial muscle. A method of detecting the velocity of motion of the heart wall without application of intravascular contrast media or surgery is needed. The means of measurement or observation would ideally be performed in the manner that the physician usually listens to heart sounds with the stethoscope. Information on the use and applicability of pulse-echo and Doppler detection methods utilizing ultrasonic or other type energy is required.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were screened and sent to the Problem Originator. The Problem Originator stated that the search results were not helpful. The Problem Originator indicated that he would like to try the Kubichek method in evaluating the condition of the myocardium. Efforts were begun to borrow Kubichek equipment for the Problem's use. Meanwhile, a Medical Problem Statement was printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Four responses to the Medical Problem Statement were received, studied, acknowledged, and forwarded to the Problem Originator. The Biomedical Application Team made arrangements for the Problem Originator to borrow Kubichek Impedance Cardiography equipment from Manned Spacecraft Center as suggested by Mr. R. E. Smylie of Manned Spacecraft Center in his Medical Problem Statement response. The Problem Originator obtained the equipment and is preparing to perform tests in his laboratory.

Projected Problem Activity: Document the Medical Problem Statement responses. Since the Problem Originator is using NASA related equipment in research work and no further action is necessary by the Team, the problem will be classified as inactive, but technology transfer will be documented as the work progresses.

Title: "Continuous Lymphocyte Destruction under Sterile Conditions"

Problem Originator: G. H. Smith, M.D., Medical Director, Chronic Home Dialysis Center, University of Texas Medical Branch, Galveston, Texas

Date Submitted: 28 April 1969

Description of Problem: Organ transplant candidates need to have their body's immune protective mechanisms suppressed so that they will not destroy the transplanted organs. What is needed is a way to selectively destroy the functioning of human lymphocytes without harming the salty, aqueous solution of plasma proteins and emulsion of fat globules which are the other constituents of the lymph. It is desirable that the destruction take place in a continuous, in-line process rather than in a batch process, and that the destroyed lymphocytes remain in the patient's circulation so that his lymphocyte production will not be stimulated by depletion of circulating lymphocytes.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator. An evaluation of the search results is still pending. Several approaches to the problem, such as radioactive sources of ionizing radiation and extra-corporeal irradiation of blood, were discussed and commercial devices were suggested. A Medical Problem Statement was printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Two responses to the Medical Problem Statement suggested the use of ionizing radiation, an approach which the Problem Originator does not favor. No formal computer search evaluation has been received, but the results have not proved to be useful to the Problem Originator.

Projected Problem Activity: Obtain a search evaluation from the Problem Originator. Document the Medical Problem Statement evaluation and close the problem.

BAYLOR UNIVERSITY COLLEGE OF MEDICINE

Title: "Computer Programs and Systems for Analysis of the Electrocardiogram"

Problem Originator: Harry S. Lipscomb, M.D., Chairman, Department of Biochemistry, Baylor University College of Medicine, Houston, Texas

Date Submitted: 9 June 1969

Description of Problem: The problem is to identify existing computer programs which provide automatic diagnostic interpretation of the electrocardiogram and to adapt portions of these programs for use on a small, multipurpose computer system which will be applicable for multiple testing of large numbers of subjects (multiphasic health screening) and more economically feasible for clinical usage.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was performed, and the screened search results were forwarded to the Problem Originator. Information on a device, developed at Mount Siani Hospital in Cleveland, that is suitable for very rapid multiphasic testing was obtained and forwarded to the Problem Originator for his examination.

Activity This Quarter and Status: The results of the computer search were screened and forwarded to the Problem Originator. The Problem Originator stated that the search results were useful but not productive of a solution.

Projected Problem Activity: Print a Medical Problem Statement and send it to the Sponsor for dissemination to the NASA Research Centers.

Title: "On-Line Analysis of Biochemical Samples Collected Automatically from Patients"

Problem Originator: David K. Brooks, M. D., Ph. D., Associate Professor of Medicine, Director of Research, Cardiovascular Intensive Care Unit, Baylor University College of Medicine, Houston, Texas

Date Submitted: 17 June 1969

Description of Problem: The problem is to develop an on-line biochemical monitoring system which will automatically collect and analyze blood and urine samples intermittently from hospitalized patients during the critical stages of their illness and recovery. The substances for which the blood, urine, and plasma samples are to be analyzed are: sodium, potassium, carbon dioxide, glucose, urea nitrogen, and enzymes such as serum glutamic oxalacetic transaminase and serum glutamic pyruvic transaminase.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was performed, and the screened search results were forwarded to the Problem Originator. A package of literature prepared from a previous search (GLM-18) and several literature searches were sent to the Problem Originator. Information on a "Urine Analyzer Unit" was requested from Jet Propulsion Laboratory.

Activity This Quarter and Status: A "Biosatellite Urinalysis" report from Jet Propulsion Laboratory was forwarded to the Problem Originator for his examination and evaluation.

Projected Problem Activity: Obtain from the Problem Originator an evaluation of the computer search of the NASA data bank and the Jet Propulsion Laboratory report.

Title: "Flexible Material for Connecting Electrical Stimuli to Nerves, Without Damage"

Problem Originator: Gerald Glick, M.D., Associate Professor,
Pharmacology and Medicine, Baylor University College of
Medicine, Houston, Texas

Date Submitted: 12 September 1969

Description of Problem: The investigator requires a biologically inert, soft, flexible conducting material for use in establishing an electrical connection between the surgically exposed carotid sinus nerve and a lead from an implanted cardiac pacemaker. The purpose of the connection is to permit electrical stimulation of the carotid nerve to relieve the crippling chest pain associated with angina pectoris, which results from overworking the heart. Major constraints surrounding the problem are that the electrode material must be a good conductor, biologically inert, and suitable for long term implantation (at least 5 years duration).

Activity This Quarter and Status: The problem was accepted and a computer search of the NASA data bank was performed. The screened search results were then forwarded to the Problem Originator. Two main problem approaches have been initiated. The first involves Mr. Salvador Rositano of Ames Research Center who has used conductive silicone rubbers for sealing gaskets in microwave horns. The Problem Originator is now in contact with Mr. Rositano and they are cooperating on the development of a silver impregnated silastic for the connecting electrode. The second approach was generated by Mr. Ralph Schleicher, Southwest Research Institute, who suggested deposition of a metal film on silastic rubber to form the electrode. This technique is now under study by Mr. Roy Clark of Langley Research Center who is a specialist in film deposition. Mr. Clark has tentatively suggested attachment of the electrode by cyanoacrylonitrile cement rather than suture. He is presently awaiting photos and sketches of the present electrode to aid in his study.

Projected Problem Activity: Forward information on the existing electrode configuration to Mr. Clark and await Mr. Rositano's development of an electrode of the impregnated silastic.

Title: "Nonthrombogenic Material for Use As A Blood Interface"

Problem Originator: John Hines Kennedy, M.D., Professor of Surgery,
Baylor University College of Medicine, Houston, Texas

Date Submitted: 17 September 1969

Description of Problem: The investigator requires a nonthromobogenic biomedical material which is suitable for use as a blood interface. In addition, the material must be non-carcinogenic and possess physical characteristics which will permit it to be processed into various configurations suitable for surgical implantation. Since there has been considerable aerospace research effort in the area of carbon, there exists a possibility that forms of carbon may have been developed which possess unique qualities rendering them suitable for biomedical applications, including surgical implantation.

Activity This Quarter and Status: Selected references available from Southwest Research Institute Biomedical Application Team files have been forwarded to the Problem Originator. A computer search statement was prepared and submitted to WESRAC.

Projected Problem Activity: Obtain samples of biocarbons for evaluation by the Problem Originator, obtain the results of the computer search, and print a Medical Problem Statement to be sent to the Sponsor for dissemination to the NASA Research Centers.

Title: "A Compound Conduit for Use With Chronically Surviving Animals:

Problem Originator: John Hines Kennedy, M. D., Professor of Surgery,
Baylor University College of Medicine, Houston, Texas

Date Submitted: 3 October 1969

Description of Problem: The investigator requires a compound conduit (umbilical) which will provide two electric leads, two pneumatic lines, and six hydraulic flexible lines to power and monitor an artificial heart implanted within an animal. One of the electric leads will be an ECG lead. The length of the required umbilical is approximately 5 meters, with the thickness being limited to about 1 centimeter by the space between the animals ribs. The umbilical should feature quick disconnectors on both ends and provide for swival action to prevent kinking as the chronically surviving animal moves around. The two pneumatic (CO₂ pressure/vacuum) lines will run respectively at +5 psig and -2 psig, with a pulsating flow approximating 0.1 liter per second. The six hydrostatic coupling columns do not involve an appreciable flow. The electrical leads must be well shielded to reduce pickup of interference on the 1 mv source impedance ECG signal.

Activity This Quarter and Status: The problem was accepted and preparations were begun to write the search statement.

Projected Problem Activity: Obtain a computer search of the NASA data bank and forward the search results to the Problem Originator.

Title: "Determination of the Physical Chemical State of Ions and Water in Living Cells"

Problem Originator: C. F. Hazlewood, Assistant Professor, Baylor University
College of Medicine, Houston, Texas

Date Submitted: 10 October 1969

Description of Problem: The problem is to determine the physical location in three dimensions of sodium ions (Na^+) within skeletal muscle fibers or other cells. The primary investigator wishes to know if NASA generated technology is or can be made available to enable measurement of this parameter.

Activity This Quarter and Status: The problem was accepted and preparations were begun to write the search statement.

Projected Problem Activity: Obtain a computer search of the NASA data bank and forward the search results to the Problem Originator.

VETERANS ADMINISTRATION SOUTHERN RESEARCH SUPPORT CENTER

Title: "Acquisition and Telemetry of Heart Rate, Blood Pressure, and Blood Flow in Free-Ranging Dogs"

Problem Originator: Joseph E. O. Newton, M. D. Research Physiologist,
VA Hospital, NLR Division, North Little Rock, Arkansas

Date Submitted: 21 October 1968

Description of Problem: Two strains of bird dogs are under study by researchers. One strain is designated "normal" and the other strain is designated "nervous." The immediate objective is to determine how such physiologic parameters as heart rate, blood pressure, and blood flow of the normal and nervous dogs compare. The ultimate objective is to learn to understand the differences between the normal and the nervous dogs; it is felt that such knowledge would be useful in understanding and treating mental illness in humans.

Wireless telemetering equipment suitable for backpack mounting is required. Transmission range should be one mile, and two channels capable of handling the blood pressure waveform and blood flow velocity must be provided. The sensors used must be implantable and must be usable with portable telemetry equipment. Service life of the system should exceed one week.

Activity on Problem to August 1, 1969: A telemetry information package from NASA/Ames Research Center was furnished to the Problem Originator. An updating NASA computer search on telemetry was performed and the screened results were forwarded to the Problem Originator. Ten documents from the updated search were ordered by the Problem Originator, who stated that he had decided to use ultrasonic Doppler equipment for measuring and telemetering blood flow velocity information. A copy of the document search for Telemetry of Body Kinesiology (RNV-11) was then sent to the Problem Originator.

The Problem Originator reported success in surgically implanting transducers around the aorta and coronary arteries and that good records of blood velocity (coronary) were being obtained. He later reported severe errors in measurement of flow velocity that the transducers did not perform properly in vivo, and that the telemetry system was noisy.

"Acquisition and Telemetry of Heart Rate, Blood Pressure, and Blood Flow in Free-Ranging Dogs" (Cont'd) SRS-8A ■

Activity This Quarter and Status:

The Problem Originator and a Biomedical Application Team member, who was in the area on other Team business, visited Dean Franklin and other members of the staff at Scripps Institute and discussed methods of use of the ultrasonic Doppler method for measuring blood flow velocity. Telemetry techniques and specific equipment functions were also discussed. Additional current technical information on performance of the ultrasonic flowmeter was sent to the Problem Originator. Requested information on the Electronics Research Center Tunnel Diode pressure transducer was sent to the Problem Originator who stated that such a device might prove useful in the solution of their blood pressure measurement problem.

A funding hiatus was experienced by the Problem Originator during part of this quarter.

Projected Problem Activity: The researcher has received new grant funds and work is in progress. Since no further action is necessary by the Team, the problem will be classified as inactive but technology transfer will be documented as the research work progresses.

Title : "Methods of Signal Categorization"

Problem Originator: Joseph E. O. Newton, M. D., Research Physiologist
VA Hospital, NLR Division, North Little Rock, Arkansas

Date Submitted: 21 October 1968

Description of Problem: Electrocardiograms from two strains of dogs are being obtained. Broadly speaking, there appear to be differences between the two categories which are observable through visual inspection by a human. What is sought is a suitable technique for quantifying this visible difference.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator. The information referenced in this search was not immediately utilized because the project had not as yet progressed to the state where methods of signal categorization was required. A Medical Problem Statement was then printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Two responses to the Medical Problem Statement, which was disseminated during this quarter, were received, studied, acknowledged, and forwarded to the Problem Originator. The Biomedical Application Team and the Problem Consultant discussed the applicability of the search results to diagnostic use in speech analysis. A funding hiatus was experienced by the Problem Originator during part of this quarter.

Projected Problem Activity

Document the Medical Problem Statement response evaluations.
Classify the problem as inactive and document the use of transferred technology as the research work progresses.

RANCHO LOS AMIGOS HOSPITAL

Title: "Materials for Prevention of New Decubitus Ulcers"

Problem Originator: E. S. Stauffer, M. D., Ph. D., Chief, Spinal Cord Injury Service, Rancho Los Amigos Hospital, Downey, California

Date Submitted: 22 September 1968

Description of Problem: Spinal cord injury patients with sensory loss develop pressure sores over the bony areas of the sitting surface while sitting in a wheelchair. These sores take from two weeks to four months to heal. Some need surgical closures. The estimated average cost of a pressure sore is \$15,000. Some type of cushion material is needed which would successfully eliminate the factor of pressure sores developing, possibly by redistributing the pressures so as to eliminate high pressure points on the patient's body. The material should be somewhat compressible, light, possibly a gel, and have properties generally described as visco-elastic.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator. The Problem Originator classified the search results as pertinent, direct, and immediately useful. Six documents were ordered from the search center by the Problem Originator. Materials were then purchased and cushion research was begun. A Medical Problem Statement was printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Responses to the Medical Problem Statement were received from Langley Research Center. The suggestions from Langley were forwarded to the Problem Originator requesting an evaluation.

Projected Problem Activity: Obtain from the Problem Originator an evaluation of the recently forwarded suggestions on the Medical Problem Statement from the staff at Langley Research Center.

STANFORD UNIVERSITY MEDICAL SCHOOL

Title: "Small Wide-Band Microphones for Sensing Heart Signals"

Problem Originator: N. Ty Smith, M.D., Assistant Professor of Anesthesia,
Stanford University Medical Center, Stanford, California

Date Submitted: 14 July 1969

Description of Problem: The Problem Originator is trying to show that nondestructive microphonic sensing techniques can produce as much reliable and valid data concerning the function of the heart in man as a traumatic procedure. Small flat circular microphones (1-2 mm thick and 1 cm in diameter) and small oval-shaped microphones (0.5 cm x 1.5 cm) are needed to sense cardiac sounds and pulse waves in man. The frequency response of the microphones should be from DC-500 Hz with the output leading into an amplifier of moderate impedance.

Activity on Problem to August 1, 1969: As a first step in processing the problem, the Problem Originator was furnished a copy of Southwest Research Institute's Technology Utilization Survey of microphones compiled by Dr. Raul San Martin.

Activity This Quarter and Status: The Problem Originator stated that the Survey of microphones supplied to him by the Team was excellent but did not contain a solution to his problem. A computer search statement was prepared. The search results were screened, sent to the Problem Originator, and his evaluation was requested. Abstracts of related technical articles and available information on potentially applicable commercial devices were forwarded to the Problem Originator. A Southwest Research Institute engineer who specializes in applications for accelerometers and microphones reviewed the problem and search results and recommended that the Problem Originator consider using an Endevco Corporation microminiature accelerometer.

Projected Problem Activity: Obtain an evaluation of the search results from the Problem Originator as well as other references supplied by the Biomedical Application Team. Consider preparation and dissemination of a Medical Problem Statement.

UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE

Title: "Ultrasonic Coupling Techniques"

Problem Originator: Donald W. Baker, Technical Manager, Bioengineering Program, University of Washington, Seattle, Washington

Date Submitted: 17 April 1968

Description of Problem: The Problem Originator is interested in increasing the efficiency of coupling ultrasonic energy from a ceramic transducer to flesh. A device or material is needed which will match the high acoustic impedance of a ceramic ultrasonic transducer to the low acoustic impedance of flesh with a minimal energy loss.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was performed and the screened search results were forwarded to the Problem Originator. The Problem Originator stated that the search results were of no direct help toward a problem solution. A Medical Problem Statement was then printed and forwarded to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: A response to the circulated Medical Problem Statement was received from Kennedy Space Center. A follow up letter was written by Mr. Crosby to the responder requesting more specific information on his mention of a transducer with an inherent characteristic acoustic impedance well matched to flesh.

Projected Problem Activity: Evaluate the current Medical Problem Statement response and await further center responses.

Title: "High Power Infrasonic Wave Generator"

Problem Originator: Donald W. Baker, Technical Manager, Bioengineering Program,
University of Washington, Seattle, Washington

Date Submitted: 18 March 1969

Description of Problem: The essential aspects of the problem are concerned with the analysis of the transmission of a stress wave along fluid filled tubes. The primary problem is the correlation between the generated dynamic stresses in experimental situations and their correlation to analog methods. What is needed now is a pressure generator that can be programmed by analog signals. The required pressures range from 0 to 300 mm Hg and with frequencies from DC to 100 cps.

Activity on Problem to August 1, 1969: It appeared from the outset of this problem that NASA technology at Ames Research Center would have real potential in the solution of the problem. Arrangements were made to borrow electro-dynamic shaker equipment from Ames Research Center for the Problem Originator's use. Mr. Jon Jacobsen, Engineer, Department of Mechanical Engineering, University of Washington, was then placed in charge of this research. A preliminary transfer report was written and submitted to Southwest Research Institute Biomedical Application Team.

Activity This Quarter and Status: It was learned that the low frequency shaker which was loaned to the Problem Originator was used at Ames Research Center in aerodynamic flutter studies and in arterial heart pulsation modeling studies. A follow up letter was sent to the Problem Originator soliciting additional information needed to write the final transfer report.

Projected Problem Activity: Obtain needed additional transfer information and complete the final transfer report and documentation.

Title: "Sensitive Detection for Human Electric Field Application"

Problem Originator: Donald W. Baker, Technical Manager, Bioengineering Program, University of Washington, Seattle, Washington

Date Submitted: 1 July 1969

Description of Problem: This problem involves the investigation and determination of extremely low-level electric fields emanating from the human body in both well and diseased humans. Instrumentation and methods of measuring and mapping these electric fields generated by humans is needed.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator.

Activity This Quarter and Status: Screened search results were sent to the Problem Originator but he has not completed an evaluation as yet. Information on equipment and facilities applicable to this problem and maintained by Ames Research Center was obtained and forwarded to the Problem Originator. Arrangements for direct discussions between the University of Washington and Ames Research Center personnel are in progress.

Projected Problem Activity: Obtain an evaluation of the search results from the Problem Originator. Attend a conference between the Problem Originator and Ames Research Center personnel.

NORTHWEST HANDICAPPED CENTER

Title: "Numerical Methods for Solutions to Wave Equations in Layered Media of Arbitrary Cross Section"

Problem Originator: Arthur W. Guy, Ph.D., Assistant Professor, Department of Physical Medicine and Rehabilitation, University of Washington, Seattle, Washington

Date Submitted: 23 September 1968

Description of Problem: For medical applications, it is desired to predict the heating in tissue due to the application of diathermy or ultrasound. The various layers encountered are fat, muscle, and bone, with cross sections that do not match the classical shapes such as cylinders and rectangles. Heat dissipation and transfer in these various layers determines the temperature rise. The use of numerical techniques for the solution of these problems will allow greater flexibility with regard to the boundaries and should also be more easily programmed for a computer solution.

Activity on Problem to August 1, 1969: A computer search of the NASA data bank was made, and the results were sent to the Problem Originator. The Problem Originator stated that the search results were most useful and informative but not directly applicable. A Medical Problem Statement was then printed and sent to the Sponsor for dissemination to the NASA Research Centers.

Activity This Quarter and Status: Responses to the disseminated Medical Problem Statements were received from Lewis (Plum Brook) and Langley Research Centers. Personnel at Ames Research Center also showed interest in the problem. The most appropriate, specific, and detailed potential solutions are those proposed by Mr. John H. Lynch, Reactor Division, Plum Brook Station; these were forwarded to the Problem Originator. The responder has also been communicating directly with the Problem Originator. Mr. Lynch's contributions are now being assayed by members of the Problem Originator's staff. Several communications have been sent to the Problem Originator by Biomedical Application Team members, citing the needs for follow up evaluations.

Projected Problem Activity: It is anticipated that the programs offered by Mr. Lynch will solve the problem. The evaluations by the Problem Originator will have to be completed, and actual use of the computer programs is expected. The problem will constitute a transfer, which will be documented.

UNIVERSITY OF CALIFORNIA AT DAVIS

Title: "Improved Measurement of Mechanical Properties of Tissue"

Problem Originator: Worden Waring, Ph.D., Associate Professor, School of Medicine, University of California at Davis, Davis, California

Date Submitted: 6 October 1969

Description of Problem: The investigator requires a non-destructive measurement scheme for determination of the mechanical properties of human tissue such as muscle and tendon. It is desired to measure such properties as stress, strain, relaxation, viscosity, and hysteresis of muscles and tendons in both normal and abnormal states. A method is needed for live testing of (human) patients, which can be done repeatedly and without pain to the patient.

Technology concepts for testing composite materials such as fiber-reinforced plastics may possibly be applicable. As an alternative to non destructive testing, a biopsy sample as minutely small as possible may be acceptable.

Activity This Quarter and Status: The problem was accepted and preparations were begun to write the search statement.

Projected Problem Activity: Obtain a computer search of the NASA data bank and forward the search results to the Problem Originator.

UNIVERSITY OF ARIZONA COLLEGE OF MEDICINE

Title: "Blood Flow of Individual Red Cells in the Capillaries of Living Tissue"

Problem Originator: Paul C. Johnson, Ph.D., Professor and Head,
Physiology Department, University of Arizona College of
Medicine, Tucson, Arizona.

Date Submitted: 30 October 1969

Description of Problem: The researcher's problem is to measure the velocity of individual red cells as they pass through the capillaries in thin tissues such as the mesenteric membrane of the intestine and certain thin skeletal muscles which can be readily visualized. Present equipment requires that as a single red cell passes two photomultiplier tube windows, identical signals must be generated. This is not always the case since the red cell may change shape or orientation as it progresses along the capillary. A better way is needed to measure the time interval between the two signals generated as the red cell passes the two phototubes, or alternatively, a different type of approach to the problem might be considered.

Activity This Quarter and Status: The problem was accepted and preparations were begun to write the search statement.

Projected Problem Activity: Obtain a computer search of the NASA data bank and forward the search results to the Problem Originator.

5. Medical Problem Statement Drafts

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

For Further Information Contact: David F. Culclasure, Ext. 648 or

Robert J. Crosby, Ext. 281, Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

15 September 1969

BLM-12

FLEXIBLE MATERIAL FOR CONNECTING ELECTRICAL STIMULI TO NERVES WITHOUT DAMAGE

Flexible electrode for electrically stimulating the carotid sinus nerve to relieve the crippling chest pain of angina pectoris, which results from overworking the heart.

The investigator requires a biologically inert, soft, flexible conducting material for use in establishing an electrical connection between the surgically exposed carotid sinus nerve and a lead from an implanted cardiac pacemaker. The purpose of the connection is to permit electrical stimulation of the carotid nerve to relieve pain associated with angina pectoris.

At the present time, a pair of rigid platinum electrodes in silicone rubber foam is used to establish the connection. This has several disadvantages: the rigid electrodes contact and stimulate only one side of the nerve and, being rigid, tends to damage the delicate nerve tissue. A soft flexible wraparound electrode is needed with a consistency much like that of Silastic rubber. The investigator has tried adding various conductive particles such as platinum and carbon to Silastic rubber, but thus far results have been variable and unsatisfactory. Major constraints surrounding the problem are that the electrode material must be a good conductor, biologically inert, and suitable for long term implantation (at least 5 years duration).

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

For Further Information Contact: David F. Culclasure, Ext. 648 or

Robert J. Crosby, Ext. 281, Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

29 October 1969

BLM-13

NONTHROMBOGENIC BIOMEDICAL MATERIAL SUITABLE AS A BLOOD INTERFACE

The investigator requires a nonthrombogenic biomedical material which is suitable for use as a blood interface. In addition, the material must be noncarcinogenic and possess physical characteristics which will permit it to be processed into various configurations suitable for surgical implantation.

In general, available materials share one major problem, i. e., they are thrombogenic, causing blood clotting when they are introduced into the blood stream. While work has been pushed forward in the area of polymer surfaces and heparinization of various materials, it is not known whether such effort has produced a completely reliable nonthrombotic material. In this regard, it has been discovered that in some instances the treatments which are applied to a material to render it nonthrombogenic may result in a surface which is highly toxic to tissue cells. Thus, factors other than thrombogenicity must be considered in evaluating a material's suitability for surgical implantation.

Since there has been considerable aerospace research effort in the area of carbon, there exists a possibility that forms of carbon may have been developed which possess unique qualities rendering them suitable for biomedical applications, including surgical implantation.

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

For Further Information Contact: David F. Culclasure, Ext. 648

Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

18 November 1969

BLM-14

COMPOUND CONDUIT (UMBILICAL) FOR USE WITH CHRONICALLY SURVIVING ANIMALS

The investigator is engaged in research which has as its overall goal the development of an artificial heart suitable for implantation in humans. At the present stage of the research effort, artificial hearts and left ventricular assist devices are being implanted within animals (calves) and then connected to external pneumatic and hydraulic power sources and various monitoring devices. An important aspect of the research involves developing a suitable means for interconnecting the implanted heart and the relatively large, complex power and monitor components.

What is needed is a compound conduit (umbilical) which will provide two electric leads, two pneumatic lines and six hydraulic flexible lines to power and monitor an artificial heart implanted within an animal. One of the electric leads will be an ECG lead. The length of the required umbilical is approximately 5 meters, with the thickness being limited to about 1 centimeter by the space between the animal's ribs. The umbilical should provide for swivel action to prevent kinking as the chronically surviving animal moves around. The two pneumatic (CO₂ pressure/vacuum) lines will run respectively at +5 psig and -2 psig, with a pulsating flow approximating 0.1 liter per second. The six hydrostatic coupling columns do not involve an appreciable flow. The electrical leads must be well shielded to reduce pickup of interference on the 1 mv source impedance ECG signal. It would be advantageous if the umbilical incorporated a quick disconnect feature on both ends, though such is not absolutely necessary for the intended application.

At the present time, the investigator employs separate flexible conduits. However, these are subject to kinking, twisting and being bitten by the chronically surviving animal, thereby interfering with conduct of the experiment. It is possible that technology associated with fabrication of astronaut umbilical devices can provide suggestions for an improved flexible compound conduit between the implanted artificial heart and external control and monitoring devices. Existing commercial technology has failed to produce a satisfactory solution to the problem.

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

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Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

18 November 1969

BLM-15

Location of Na Ions in Living Skeletal Muscle Fibers and Other Cells

The investigator is engaged in basic research involving efforts to expand the existing fund of knowledge concerning muscular dystrophy. This research is part of a large overall effort to devise preventive and therapeutic measures to combat the disease.

An area of the investigator's research involves development of a theoretical explanation of muscle cell polarization. However, achieving a theoretically sound explanation for the phenomenon requires detailed knowledge concerning the physical-chemical state of cellular ions and water within the living cell. In this connection, the investigator's ongoing research suggests that certain ions may be bound or adsorbed to cellular macromolecules (Hazlewood, CF, and Nichols, B.L., The Johns Hopkins Medical Journal, 123: 198-203, 1968), with other investigators (Cope, F.W., J. Gen. Physiol., 50: 1353, 1967) reporting direct evidence for sodium adsorption. These findings give rise to such important and relevant considerations as: If ions are indeed bound, may they not be physically sequestered in certain portions of the cell, and if so, where are the ions located and with what subcellular structures are they associated? Answers to such questions can be expected to provide insight into the functional significance of the relationships involved, thus helping to substantially advance research in this important area of basic medical research.

At this point, the investigator is seeking information concerning whether there are methods which exist within NASA technology which can be used, or adopted for use, to establish the three dimensional location of Na ions within skeletal muscle fibers or any other living cells in order that answers to practical and theoretically relevant questions such as those posed above can be formulated.

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

For Further Information Contact: Robert E. Schuhmann, Ext. 565 or

Charles J. Laenger, Ext. 767, Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

2 November 1969

DVM-1

NON-DESTRUCTIVE IN-VIVO MEASUREMENT OF MECHANICAL PROPERTIES OF TISSUE

The investigator requires a non-destructive measurement scheme for determination of the mechanical properties of human tissue such as muscle and tendon. It is desired to measure such properties as stress, strain, relaxation, viscosity, and hysteresis of muscles and tendons in both normal and abnormal states.

A method is needed for live testing of (human) patients, which can be done repeatedly and without pain to the patient. By this means the changes in long-term recovery of the tissues can be evaluated and gains or losses in muscle function may be correlated in various treatment programs and pathological conditions. The benefits to society would be not only in analysis and synthesis of rehabilitation programs, but also in the analysis of deterioration in injury and disease.

Technology concepts for testing composite materials such as fiber-reinforced plastics may possibly be applicable. As an alternative to non-destructive testing, a biopsy sample as minutely small as possible may be acceptable.

MEDICAL PROBLEM STATEMENT

PREPARED FOR THE NASA BY: Southwest Research Institute

For Further Information Contact: Robert L. Wilbur, Ext. 727, or

Louis S. Berger, Ext. 647, Southwest Research Institute, Dept. 13

Phone No. 512-684-2000, 8500 Culebra, San Antonio, Texas 78228

6 November 1969

TCM-1

BLOOD FLOW OF INDIVIDUAL RED CELLS IN THE CAPILLARIES OF LIVING TISSUE

Hematological studies conducted at the University of Arizona under a NIH grant include the measurement of velocity of individual erythrocytes as they travel through capillaries. Thin skeletal muscles or mesenteric tissues are utilized as they can be readily visualized. Present techniques measure the time interval of the passage of the erythrocyte between two phototube-slit arrangements. If the erythrocyte changes orientation, as it often does, the analog circuits do not trigger at the correct time yielding erroneous velocity data. Dr. Johnson is interested in determining if NASA technology is available that could be adapted to his program.

D. PARTICIPATION IN SYMPOSIUMS AND MEETINGS

Dr. Ray Ware attended the Arizona Hospital Association Meeting at Phoenix, Arizona on 2 and 3 October 1969, to acquaint attendees with the Biomedical Application Program.

E. COMMERCIAL PRODUCT AND/OR APPLICATION ENGINEERING ACTIVITY RESULTING FROM TEAM OPERATIONS

No candidate reengineering projects have emerged from the new problems for this quarter. Upon re-examining some of the older problems, seven were screened where engineering, hardware fabrication, hardware modification, engineering test, or equipment provision would materially assist the Problem Originator. None of these candidate reengineering problems, which were compiled prior to the Reengineering Procedural Guidelines Conference at the University of Virginia, survived the screening for the reasons shown in the following chart.

<u>Problem No.</u>	<u>Equipment or Activity</u>	<u>Reason it is Not Appropriate</u>
1. GLM-15	ERC Respirometer. Convert to volumetric.	A fundamental development of large magnitude.
2. SRS-8A	Validation and improvement of Ultrasonic Blood Measurement.	A development program requiring extended effort.
3. SRS-8A	Reduce co-channel interference in commercial version of NASA/Ames Telemetry.	Commercial problem. Task should be performed by the Problem Originator or a commercial concern.
4. GLM-5, SRS-8A <u>et. al.</u>	Tunnel Diode Transducers, ERC.	Equipment provision.
5. SFM-6	Reduce size and Mass of Phonocardiograph pickup, NASA/Ames.	A development program requiring extensive effort.
6. SRS-8A & SRS-1	Wanted - A dual channel ultrasonic Doppler blood pressure system.	Equipment provision.
7. GLM-14 GLM-16	Wanted - Ultrasonic Bone Scanner, MSFC.	Equipment fabrication.

F. INSIGHTS

It became clear as a result of several conversations with potential Problem Originators and other physicians that an important aspect of the program, well understood by long-term participants in the program and perhaps taken for granted by them, may have received insufficient emphasis during early contacts with new potential Problem Originators. It has long been felt, and is consistent with the program objectives, that the greatest opportunities for help to biomedical researchers lie not in furnishing information on NASA's work in biology, but in discovering enabling technology which can be transferred from the physical sciences and engineering to biomedical applications: Since the researchers are experts in their respective biological areas, in many cases directly or indirectly working with NASA in these areas, they develop a high degree of awareness of current parallel biological work in and outside the aerospace sector; however, where they may need help and where their background usually is restricted is in solving physiological science/technological problems, important to their research, which are in areas outside the researchers direct training and experience. For example, although the staff at Texas Institute for Rehabilitation and Research is of course extremely knowledgeable in the areas of patient retraining, physical concepts leading to a good reduced gravity simulator design are less familiar to the staff members. Similarly, at the University of Washington, researchers are intimately familiar with the biomedical problems associated with cardiovascular stress and the effects of physical workloads; however, when they face the problem of obtaining rapid, large temperature changes in a patient's environment, they can well use assistance from appropriate areas in physical science. Both of these research problems were materially helped by application of non-medical aerospace technology.

In recent briefings, the above line of argument was emphasized and carefully presented. From the kinds of potential problems that were subsequently mentioned and discussed by the researchers, it seems that this emphasis can help to lead the researcher into fruitful areas of problem submissions. We therefore plan to continue emphasizing this aspect of the project, especially in our initial contacts with a potential Problem Originator.

G. PLANS FOR FOLLOWING QUARTER

1. New Institutions

Immediately after renewal of our project, we are geared to actively move into the following new institutions. Initially we propose to start with expanding our West Coast effort to embrace seven additional California medical schools. The reasonably close proximity of these institutions will permit conservation of travel funds by switching to a modified "circuit-rider" approach, which in turn can be expected to introduce greater efficiency into our team operations.

Proposed potential users to be acquired at a later date are:

University of Colorado School of Medicine
University of Oklahoma Medical Center
University of Texas Dental Branch at Houston
Medical School, University of California, Irvine
Medical School, University of Arkansas
Loma Linda University School of Medicine, California
Medical School, University of Southern California
Medical School, University of California, Los Angeles
Medical School, University of California, San Diego
Medical School, University of California, San Francisco
Medical School, University of Oregon
Medical College of Alabama
Medical School, University of Miami
Medical School, University of Florida
Scott-White Clinic and Memorial Hospital, Temple, Texas
Ben R. Meyers Rehabilitation Center at Cedars of Lebanon Hospital,
Los Angeles
Veterans Administration Hospital, Temple, Texas
Veterans Administration Hospital, Kerrville, Texas
Veterans Administration Hospital, Houston, Texas
Medical School, Boston University, Massachusetts
Harvard University Medical School, Massachusetts
Tufts University School of Medicine, Massachusetts
Chicago Medical School, Illinois
Medical School, Northwestern University, Illinois
Loyola University Stritch School of Medicine, Illinois
University of Chicago Pretzker School of Medicine, Illinois
Medical School, University of Illinois

2. Circulation of Medical Problem Statements

It was mentioned elsewhere in this report (Section B. 1) that ten Medical Problem Statement drafts have appeared in this and the previous Quarterly Progress Report. These drafts will be reviewed (and if need be, revised) at a rate of about three per month along the guidelines suggested by Dr. William H. Clingman, Consultant to NASA in this problem area. The completed Medical Problem Statements will be forwarded to the Sponsor for approval as they become available.

3. Problem Activity

The twenty problems remaining active at the end of the current reporting period will be processed according to the plans discussed in Section C. 4. A continued effort will be made to deactivate those problems which clearly are not leading toward a technology transfer.

APPENDIX A

AID TO RESEARCHERS ON POTENTIAL PROBLEMS

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In the course of the performance of project work there are, occasionally, special services which we render that are not connected to active Team problems. The following is a chronological listing of these services.

1. Mr. Berger sent the Problem Originator of SFM-9P (rejected) a brochure on a small cassette recorder system put out by MEDTEC.
2. Mr. Buck sent the Problem Originator of SFM-9P information on a new Hewlett-Packard Co. 4-channel tape recorder.
3. Mr. Buck sent the Problem Originator of SFM-7P (rejected) various commercial equipments catalogs.
4. In the monthly report for June, 1969, Section B. 4 described the tabling of problem PLR-5P, and gave the rationale for not processing the problem at that time. We have received a report that Mr. Berger's recommendation to contact Professor Eden at MIT had been followed up by the Problem Originator, that he had met with Dr. Eden and an associate, Dr. Robert Archer, and that future cooperation with MIT is entirely possible.
5. As a result of preliminary conversations with the Dean of the Medical School at the University of Arizona, some time was spent with Mr. James E. Peebles, Director, Division of Data Processing, at the College of Medicine. Mr. Peebles was informed about the existence of COSMIC, and he was also referred to his counterpart at the Research Data Facility, Prysbyterian Medical Center, San Francisco (Mr. R. P. Abbott).
6. Mr. Crosby sent Mr. Canzoneri of TIRR a clipping of an advertisement for a pressure transducer intended for use in prosthesis.
7. Dr. Rudenberg sent Dr. Wooten, Research Triangle Institute Research Engineer, helpful articles on two RTI problems.
8. Mrs. Wall sent Dr. James Brown, Research Triangle Institute, information on two RTI problems (VU-1 and UNC-53).

9. Mr. Berger wrote a letter to Dr. Alan Levy at the Computer Center, Baylor School of Medicine, and enclosed information on hospital scheduling techniques (HUV-3 and HUV-7) and invited him to submit problems in these areas of interest to him.
10. Mr. Laenger sent the Problem Originator of the rejected problem SFM-7P a copy of an OAR March-April 1969 paper, "Control Theory--Physical Systems."
11. Mr. Berger sent Mr. Jack Johnson information from an upcoming Acoustical Society of America Meeting on current work in the diagnostic applications of speech analysis.
12. Information on miniaturized implantable telemetry equipment was sent to the University of Utah by Mr. Berger.
13. A Technical Support Package on ambulance/telemetry technology was furnished, upon request, by Mr. Clinton Johnson of Edwards Flight Research Center. Dr. Ware had discussed possible application of this technology to helicopter air evacuation at St. Joseph Hospital in Phoenix, during a recent Hospital Association meeting there, and interest was expressed in this technology.

APPENDIX B

TRANSFER REPORT FOR PROBLEM SFM-3

TRANSFER DESCRIPTION

Problem Code: SFM-3

Problem Title: Improved Monitoring of Heart Cell Parameters

Researchers Name: Mr. Harry A. Miller
School of Medicine
Stanford University

Biomedical Team Member Responsible for Problem: Andre G. Buck
and Charles J. Laenger, Sr.

Date Problem Acquired: August 1968

Date Transfer Made: August 1969

Elapsed Time to Complete: 12 months

Description of Problem: The researcher is investigating the effect of various pharmacological agents upon several parameters of isolated heart cell activity, such as rate of contraction. At the time the problem was submitted, observation of this cellular activity was performed visually on periodic basis by a human observer using a phase contrast microscope. An automated system was needed to provide for continuous monitoring of heart rate.

Description of Solution: Several avenues were utilized to effect a solution to the problem, including computerized search of the NASA data bank and liaison with researchers at various NASA research centers. A data search failed to yield a solution to the problem; however, it provided much valuable information for the researcher. Solution to an important portion of the problem was attained with assistance provided by Mr. John Pope, Instrumentation Division, Ames Research Center, National Aeronautics and Space Administration, who had previously developed a linear, low-frequency response cardiometer for employment in animal experimentation. While in its existing form the NASA-developed tachometer failed to meet the precise requirements of the researcher. NASA was able, by some reengineering effort, to modify the equipment to meet the researcher's needs. This involved circuit modifications designed to provide a lower linear frequency limit of 10 bpm, which was needed for the researcher's particular application. Prior to reengineering the NASA tachometer's lower linear frequency limit was 30 bpm. The reengineering effort also involved development of an improved interface between the recording apparatus and the cardiometer, facilitating use of the NASA-developed tachometer in the research effort.

Benefits: Research of the nature described above, in which the effects of various pharmacological agents are evaluated upon isolated cardiac cells, is expected ultimately to lead to techniques whereby localized heart therapy will be possible. That is, instead of being constrained to treat the entire heart, the techniques will permit treatment of localized, damaged or diseased areas of cardiac musculature. In terms of benefits to the researcher, the NASA-developed and reengineered cardiometer facilitated research progress by providing a means for continuously, automatically monitoring activity of isolated heart cells or clones of cells. Prior to availability of the NASA equipment, observations were crudely performed by visual observation using a phase contrast microscope, during which time the cellular contractions were counted. Out of practical necessity, this important phase of the research had to be accomplished on a periodic rather than on a continuing basis. The NASA-provided equipment substantially increased the accuracy of observations, saved untold man-hours of observational effort, and significantly expedited progress on the overall research task. In addition, the data provided by the computerized search proved to be extremely useful to the researcher in proceeding toward development of a mathematical model dealing with the force--or amount of work--involved in the contraction of cardiac cells.

Consultants: Mr. Jack M. Pope
Instrumentation Division
NASA-Ames

Cost/Effort

- (a) Professional Man Hours: Team 34;
Machine Search: 2 performed.
- (b) Estimated Dollar Cost: \$800 (charged directly to this problem).